



2017

# Laboratory Exercise – Frontrunner Extension

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## Recommended Citation

Apelu, Meeya; Arrowchris, Jordan; and Browning, Joseph, "Laboratory Exercise – Frontrunner Extension" (2017). *Engineering Applications of GIS - Laboratory Exercises*. 11.  
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# Laboratory Exercise – Frontrunner Extension

## Background

The Utah Transit Authority's (UTA) FrontRunner is a commuter rail line that runs 89 miles through Weber, Davis, Salt Lake, and Utah counties. There are 16 different stops along this line which are: Pleasant View, Ogden, Roy, Clearfield, Layton, Farmington, Woods Cross, North Temple, Salt Lake Central, Murray Central, South Jordan, Draper, Lehi, American Fork, Orem and Provo (UTA 2017). Using the FrontRunner is easy and is very convenient. The popularity of this transit system is increasing and UTA has announced their future plans to continue the rail line. UTA is exploring ways to go forward with this plan and in choosing future destinations to extend the transit path. ArcGIS Model Builder is well suited to assist in this process and answers the questions concerning the construction of this project.

As a GIS professional you may be called upon to perform an analysis and create models that address the placement of the rail line. The placement of a rail line is a complex modeling topic and requires a lot of spatial consideration. While in many cases a least cost path between two points would be a single connecting line, engineering limitations and topography make the modeling of a least cost path very difficult. Additionally, when the court of public opinion is figured into the process, models of least cost can negate the feasible placement of a line, which then in return requires rethinking of the whole process.

A GIS professional will be called to adjust all input of the model in order to satisfy all parties. The creation of an ArcGIS model is of great importance. Additional layers, weights on those layers, and changing requirements can adjust the ultimate cost path. The purpose of this lab is to familiarize you with a few of the processes and requirements that might be used in the modeling of a least cost path for the FrontRunner rail line. You will not be asked to factor social considerations in this model, but will consider engineering aspects of the process.

## Problem Statement

This lab simulates the construction of a least cost path for continuing the UTA FrontRunner line from Provo Central Station in Provo, UT to Zion National Park near St. George, UT.

## Spatial Considerations

Using ArcGIS Model Builder and the data supplied, create a model that will generate a least cost path considering the following criteria:

- The start point will be at the Provo FrontRunner Station as the current line runs from Ogden to the south, ending at Provo.
- The end point will be in Hurricane, UT, next to I-15. The purpose of this location is its proximity to Zion National Park. Additionally, a steep descent exists to make the final trip to St. George, which may be better served by a bus line.

- The rail line should run through six different counties, including Utah, Juab, Millard, Beaver, Iron, and Washington.

Use a uniform scale factor when using the raster calculator/reclassification tools to determine what locations would be suitable for building a rail line. This will aid in weighting the costs evenly.

## Data

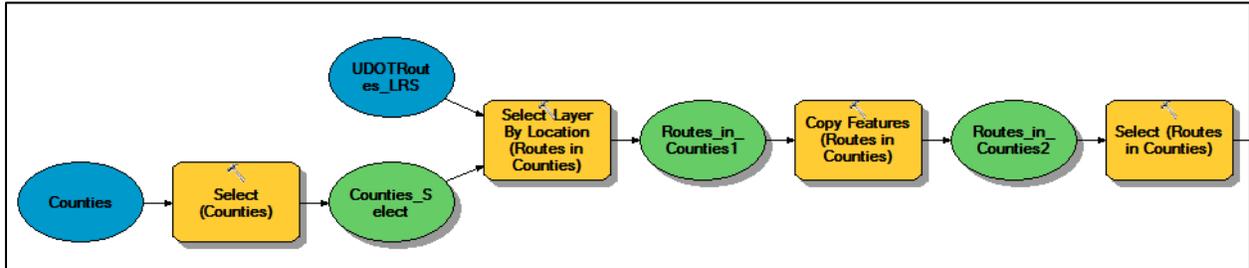
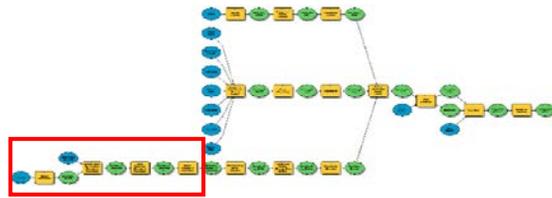
- <http://gis.utah.gov/data/boundaries/citycountystate/> Utah Counties Shapefile: You can find a shapefile that represents all the counties from Utah. Select the “Links/Download” tab. You should download the “County Boundaries: Shapefile,” which will download in a zipped file.
- <http://gis.utah.gov/data/sgid-transportation/roads-system/> UDOT Highways: You can find a shapefile that represents all the major roads and highways in Utah. For the “Highway Linear Referencing System Routes” section select the “Links/Download” tab. You should download the “UDOT LRS Routes: Shapefile.” This will download in a zipped file.
- <http://gis.utah.gov/data/elevation-terrain-data/10-30-meter-elevation-models-usgs-ned/> NED (National Elevation Dataset): You will need to download this meter elevation dataset for Utah provided by the USGS. You should either download the 10m or 30m NED for Utah, Juab, Millard, Beaver, Iron, and Washington Counties using any of the methods on the page.
- <http://gis.utah.gov/data/water-data-services/lakes-rivers/dams/> Utah Lakes: You will need to download a shapefile that contains all known water bodies in Utah. Using the “NHD Lakes” section, download the “Lakes NHD High Res: Shapefile” link.

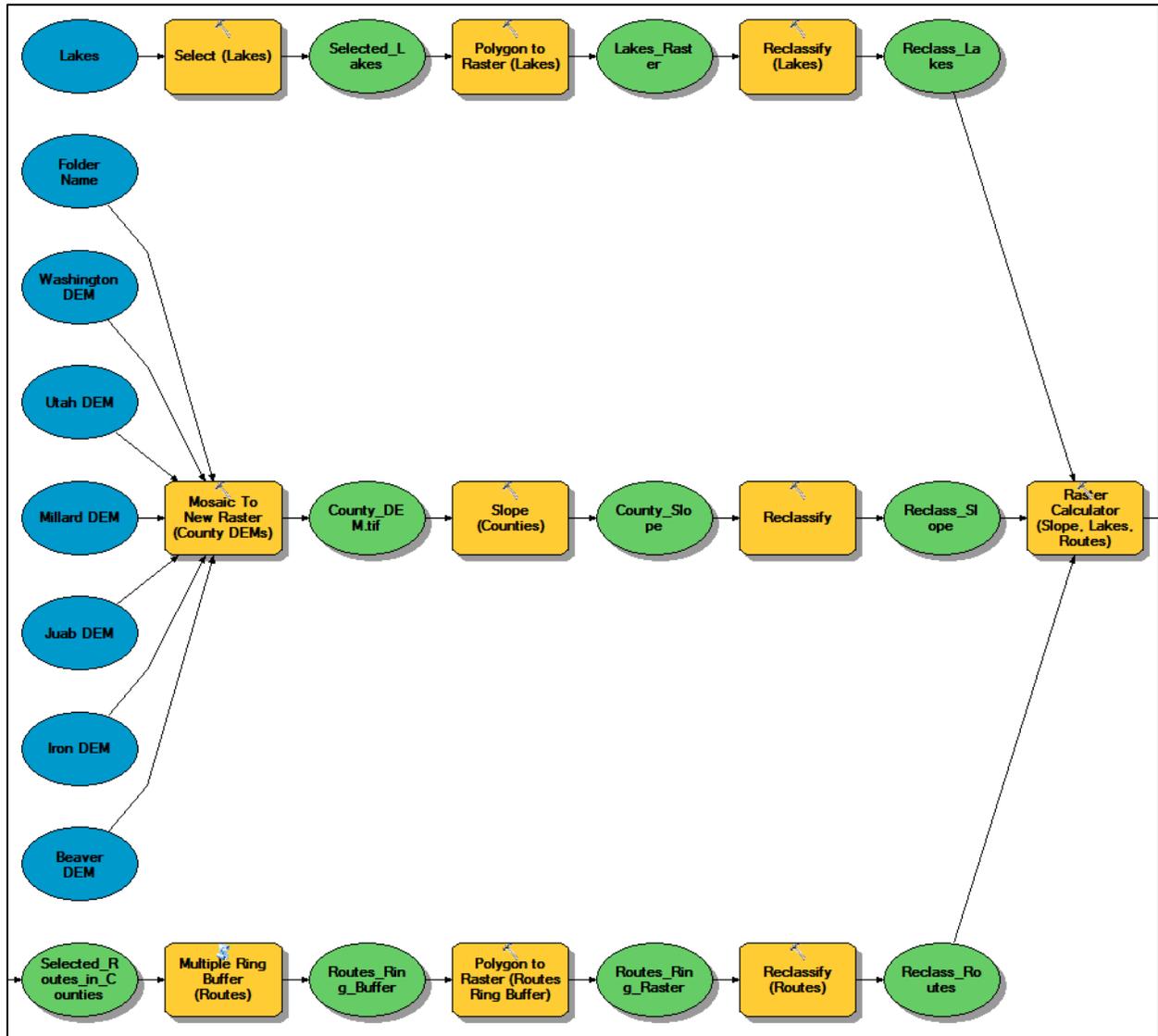
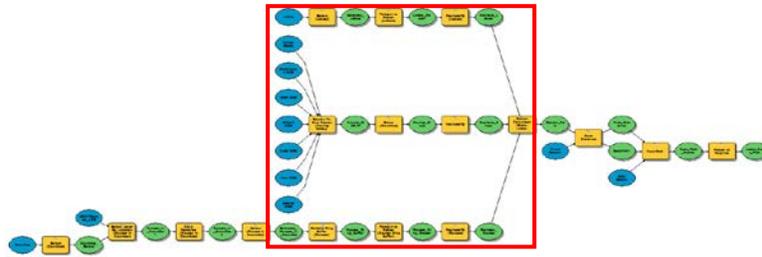
## ModelBuilder Tools

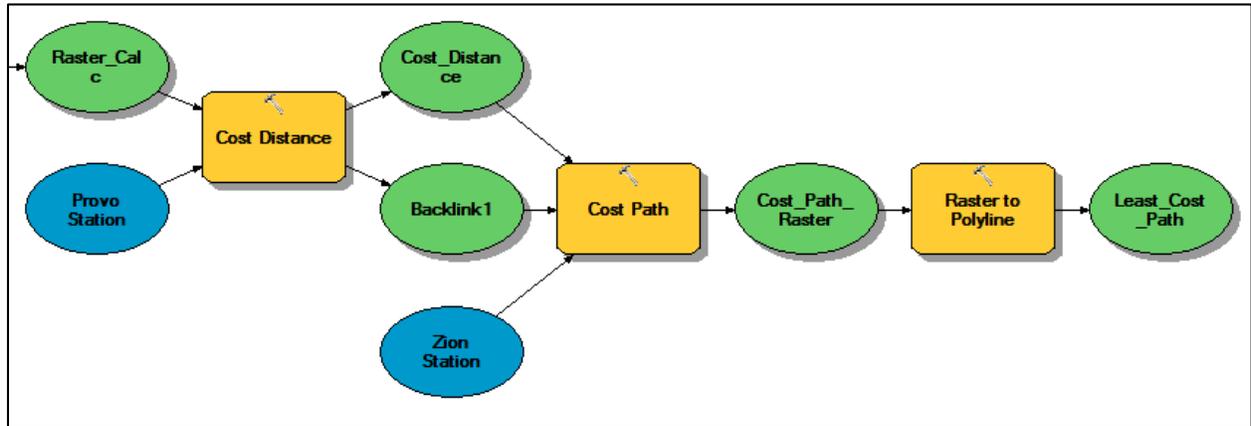
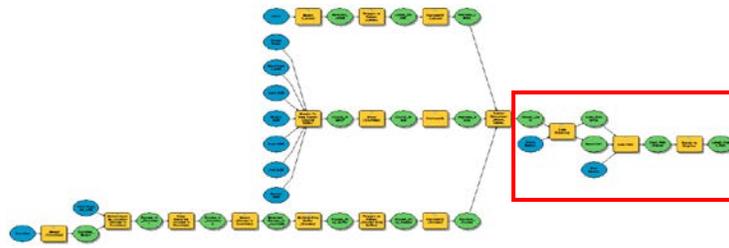
In this exercise you may use previous tools and will use the following new tools.

- Select Layer by Location selects individual objects in a layer based on a user-defined location, which can be bounded by polygons or a raster, or an intersection with polylines.
- Copy Features copies the selected parts of a layer, if any are selected, and exports them to a new layer.

# Example Model







## Step by Step Solution

For an advanced GIS student, the information up to this point is all you need to complete the assignment and create an output map from the results. Feel free to try conducting the analysis using only the information provided above. If you need specific steps, follow the instructions.

### Step 1

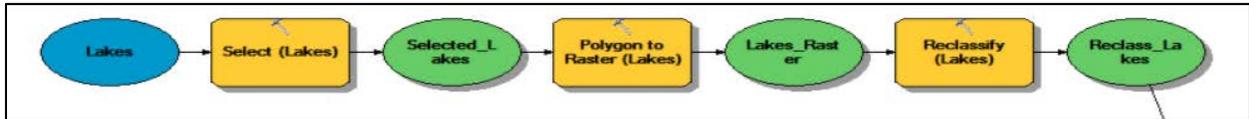


Figure 1 - Using the Polygon to Raster and Reclassify Tool for the Lakes Shapefile

The suitable lake size requirement is defined as greater than 1,000,000 ft<sup>2</sup>. Any lake that is less than this size will not be taken into consideration for this lab. The “Select” tool is used to identify these suitable lakes by using the following expression: “**SHAPE\_Area**” >1000000. The “Polygon to Raster” tool is then used to turn the selected lake shape files into raster files using the following settings: Value field = OBJECTID, Cell Assignment Type = CELL\_CENTER, Priority Field = NONE, and Cellsize = 2200. The “Reclassify” tool is used next and an example of the reclassification settings can be found in Figure 2 and Figure 3.

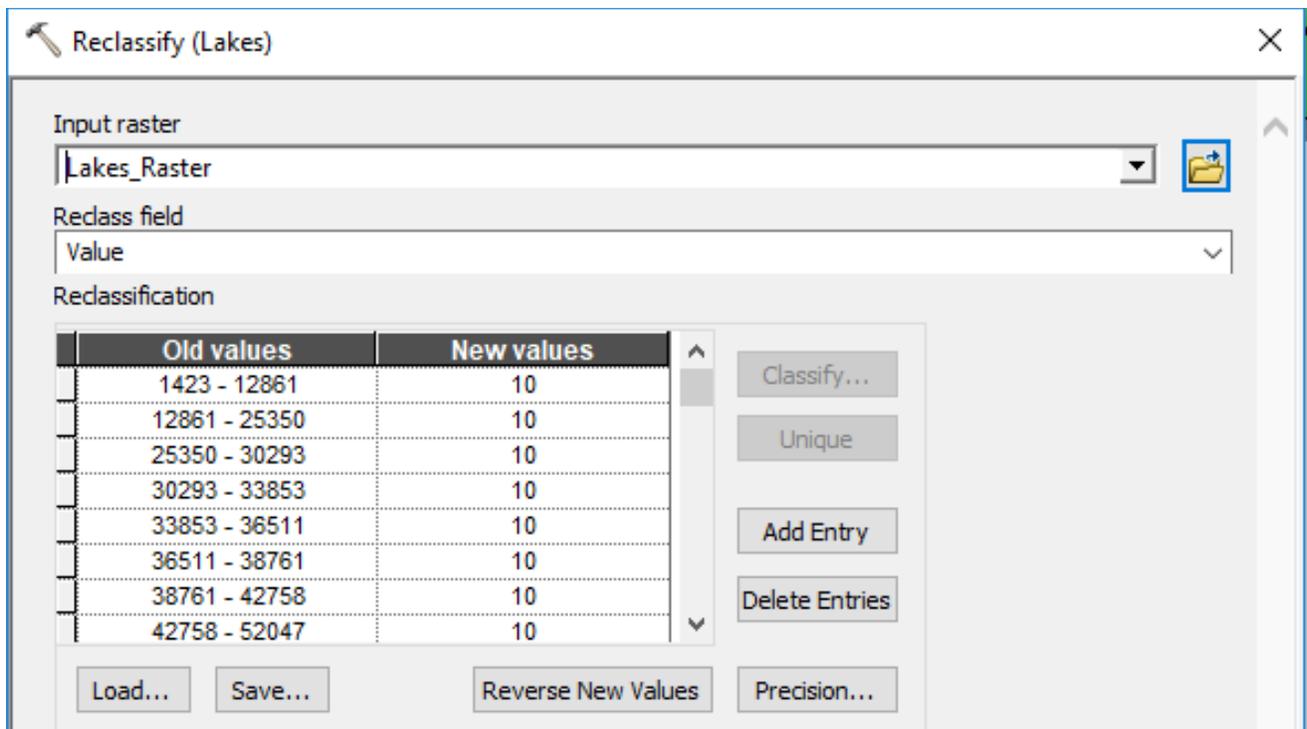


Figure 2 - Reclassify (Lakes) Tool Settings

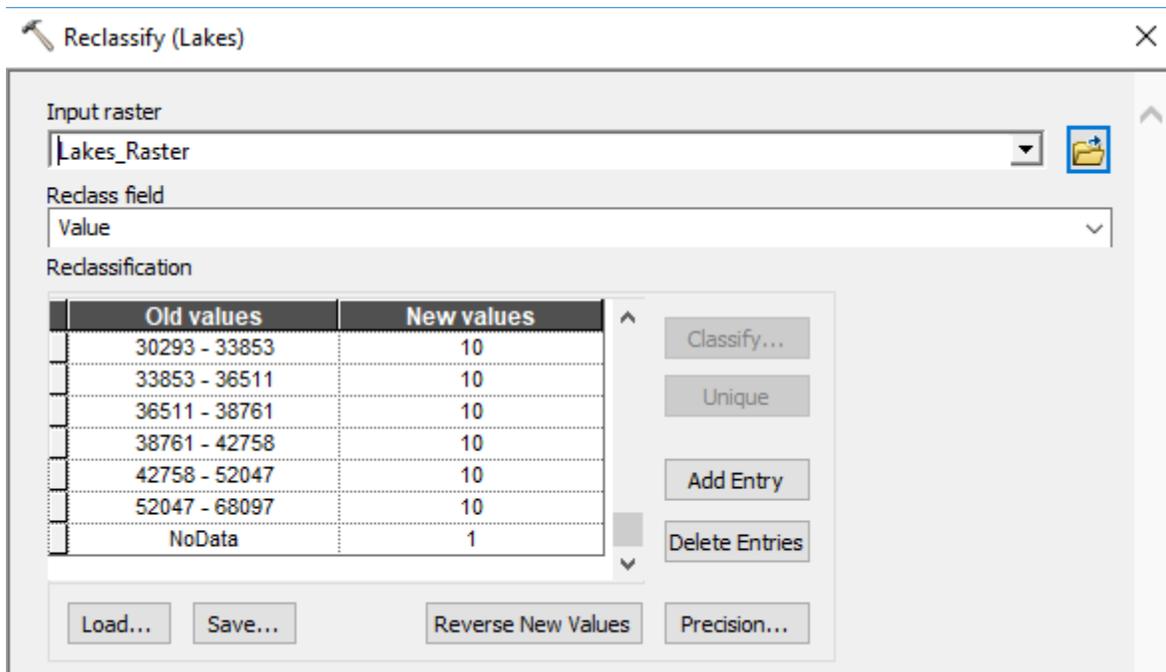


Figure 3 - Reclassify (Lakes) Tool Settings

## Step 2

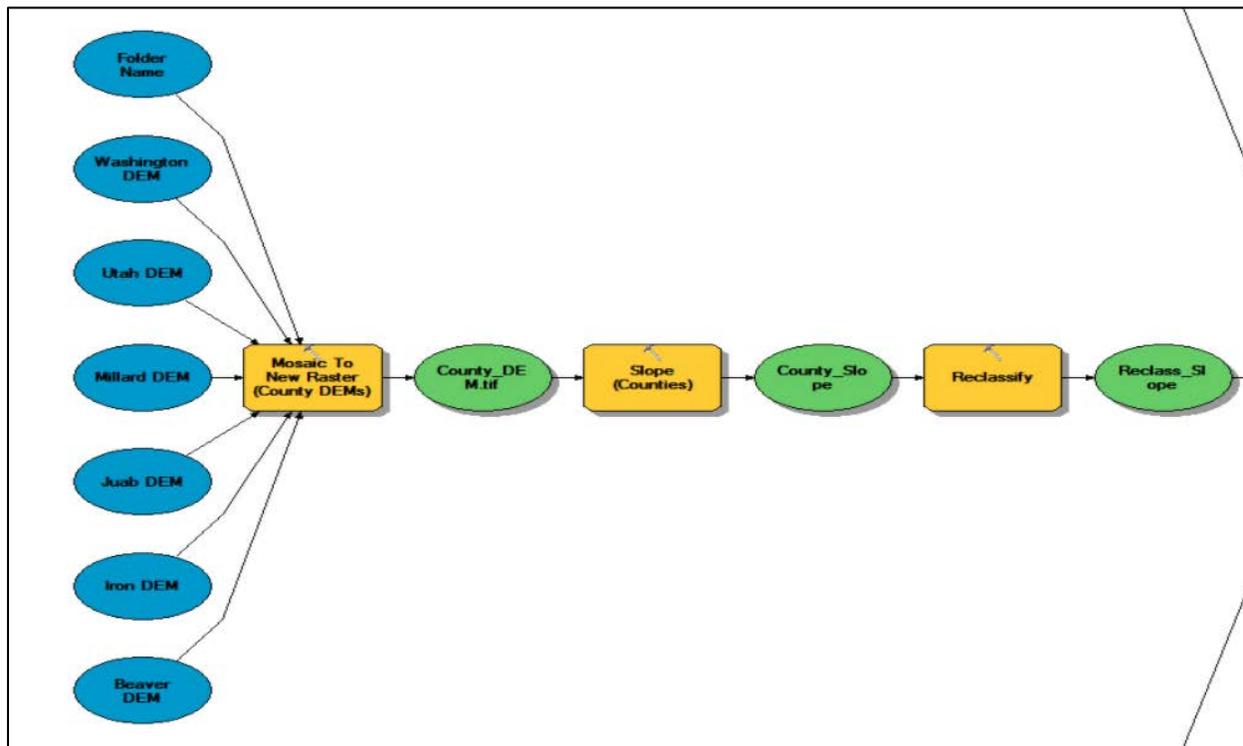


Figure 4 - Using the Mosaic to New Raster, Slope, and Reclassify Tools in Model Builder

Then, the DEM datasets for each county are combined using the “Mosaic to New Raster” tool. The settings used for this tool can be found in Figure 5. The suitable slopes are then

identified by using the “Slope” and “Reclassify” tools. The settings used in the “Reclassify” tool can be found in Figure 6 and Figure 7.

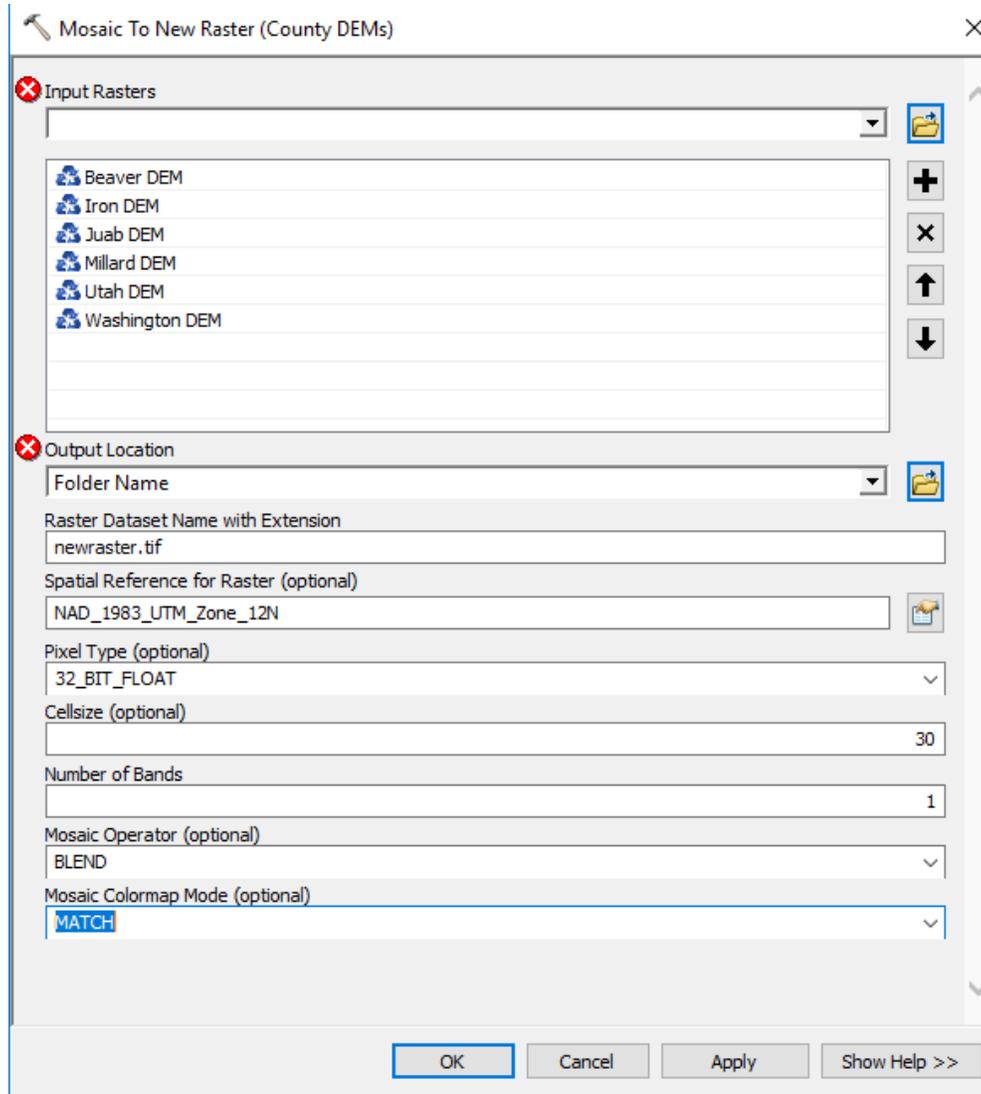


Figure 5 - Mosaic to New Raster Tool Settings

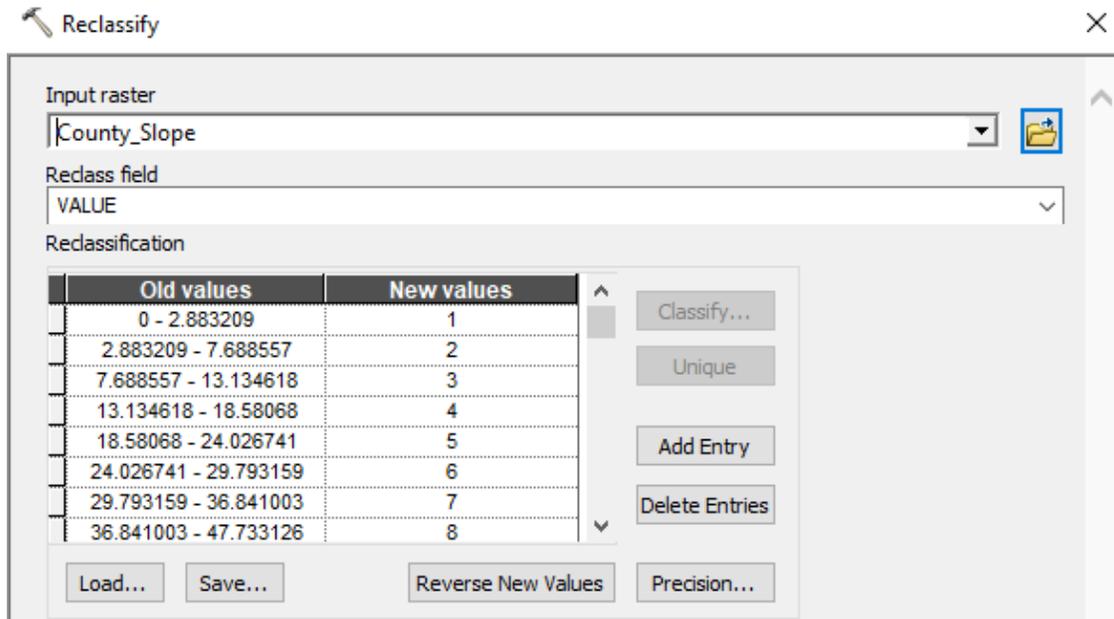


Figure 6 - Reclassify Tool Settings Used for Slope

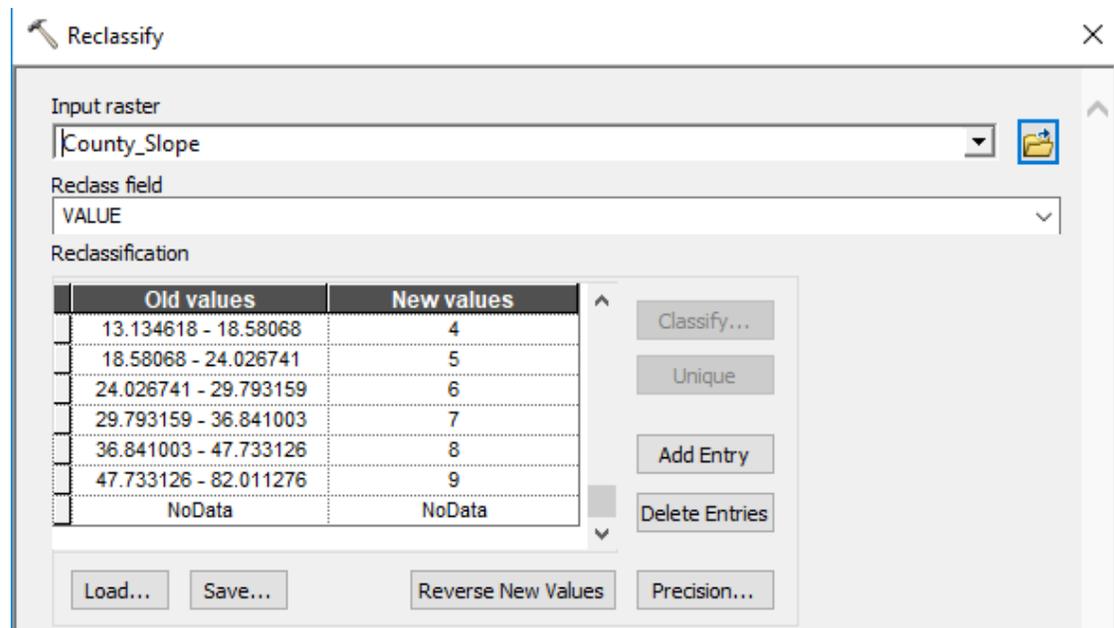


Figure 7 - Reclassify Tool Settings Used for Slope

### Step 3

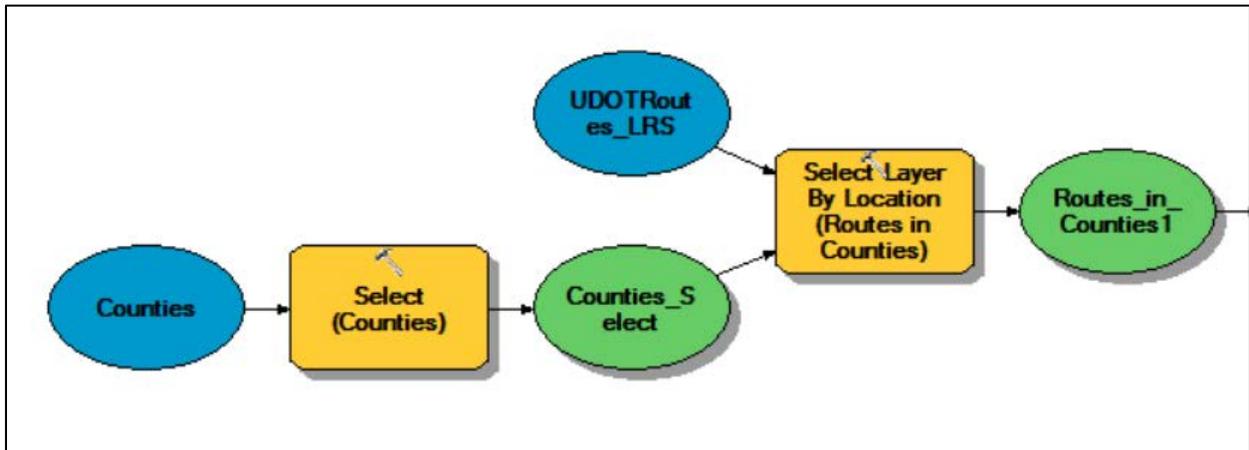


Figure 8 - Using the Select Layer by Location Tool for the UDOT Routes LRS Shapefile and for the Specified Counties

To find the desired counties needed for this lab, the “Select” tool is used with the following expression: **“NAME” = ‘BEAVER’ OR “NAME” = ‘JUAB’ OR “NAME” = ‘MILLARD’ OR “NAME” = ‘UTAH’ OR “NAME” = ‘WASHINGTON’ OR “NAME” = ‘IRON’**. The “Select Layer by Location” tool is then used to create a file containing the routes located in the previously specified counties. This is done using the following settings: Relationship = COMPLETELY\_WITHIN, Selection type = NEW\_SELECTION.

### Step 4

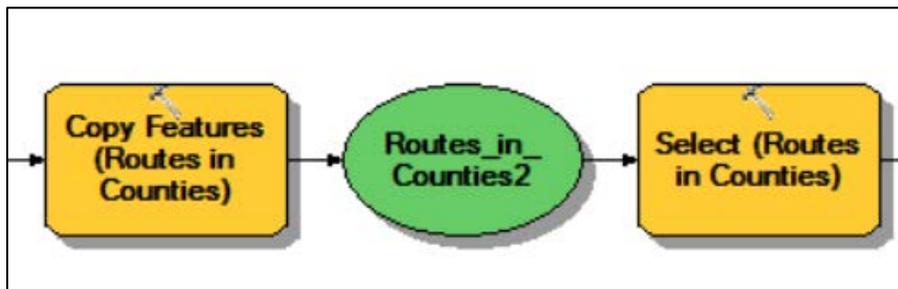


Figure 9 - Using the Copy Features and Select Tools in Model Builder

With the routes now only located within the desired counties, the features of the routes can now be transferred to a new feature class by using the “Copy Features” tool. Then, the “Select” tool can be used to select the routes located within the counties.

## Step 5

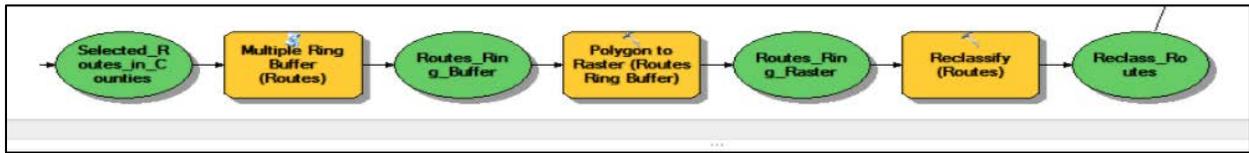


Figure 10 - Using the Multiple Ring Buffer, Polygon to Raster, and Reclassify Tools in Model Builder

With the routes now selected from the new feature class, the “Multiple Ring Buffer” tool can be used to create multiple buffers around the routes at specified distances. Distances of 50, 100, 150, 200, 250, and 300 feet will be used for this lab. The reason for this is that building a rail closer to an existing UDOT route lowers the cost of land purchasing, while building costs may increase if it is too close to an existing route. With the routes now buffered with their desired distance rings, the “Polygon to Raster” tool can be used to convert the data into a raster dataset. This allows the data to now be manipulated by the “Reclassify” tool. An example of the settings used in the “Reclassify” tool can be found in Figure 11.

Reclassify (Routes)

Input raster: Routes\_Ring\_Raster

Reclass field: Value

Old values	New values
50	3
50 - 150	0
150 - 250	1
250 - 300	2
NoData	4

Buttons: Classify..., Unique, Add Entry, Delete Entries, Load..., Save..., Reverse New Values, Precision...

Figure 11 - Reclassify Tool Settings Used to Reclassify the Routes

### Step 6

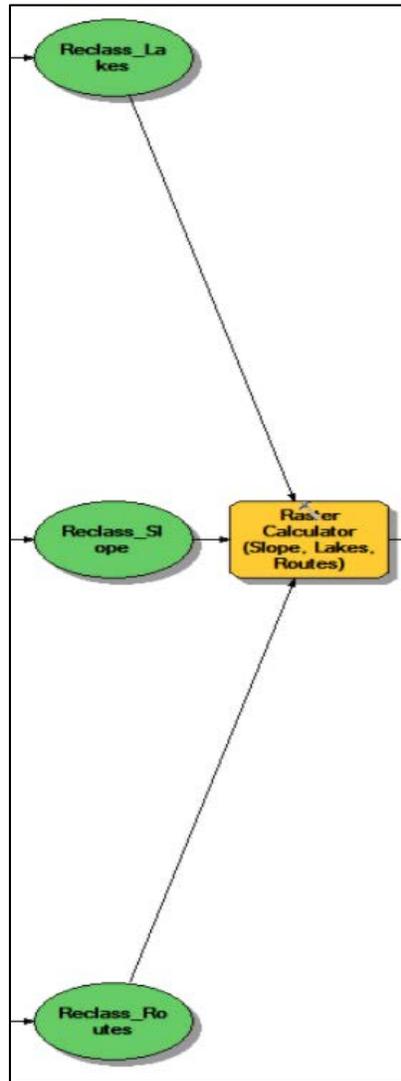
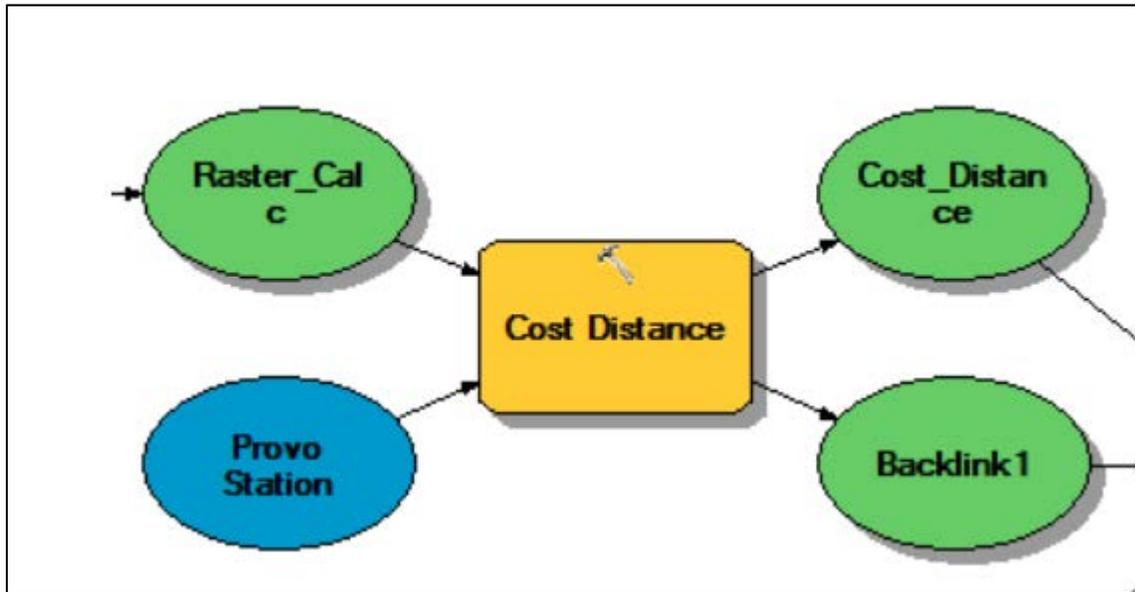


Figure 12 - Using the Raster Calculator Tool in Model Builder

With the slope, lakes, and routes now reclassified, the “Raster Calculator” tool can be used to combine the 3 raster datasets into 1 dataset. This is done by using the following statement: **“%Reclass\_Routes%” + “%Reclass\_Lakes%” + “%Reclass\_Slope%”**.

*Step 7*



*Figure 13 - Using the Cost Distance Tool in Model Builder*

Using the new combined raster dataset, the least accumulative cost distance from Provo Station can be calculated by using the “Cost Distance” tool. This tool requires the user to specify an input raster (Provo Station), an input cost raster (Raster\_Calc), and for this lab an output backlink raster (Backlink1).

## Step 8

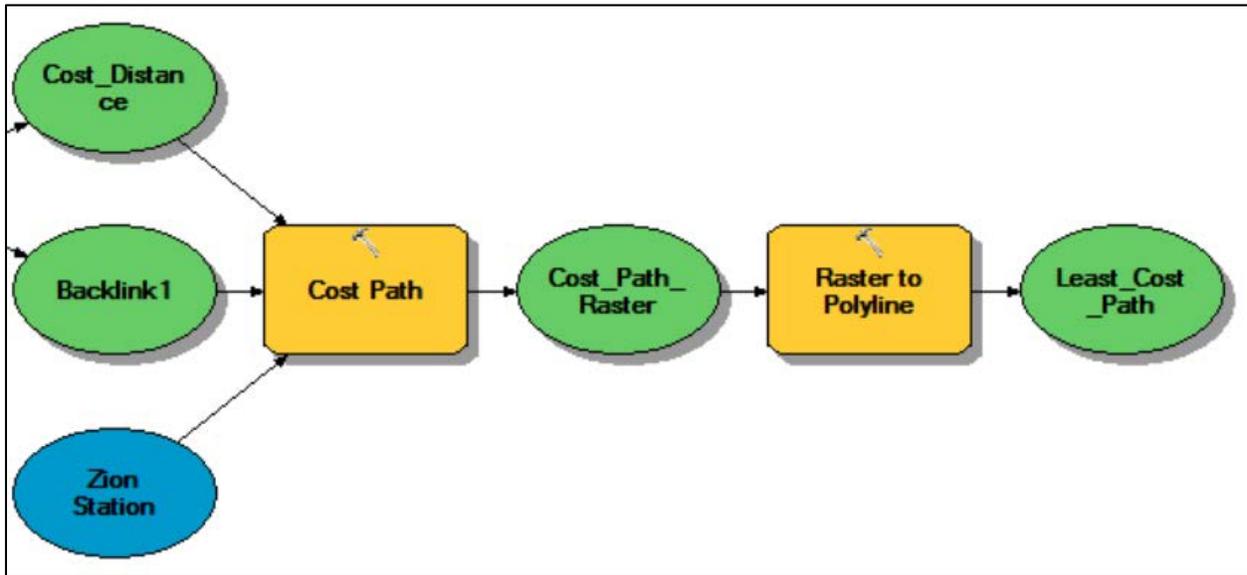


Figure 14 - Using Cost Path and Raster to Polyline Tool in Model Builder

The final step needed to calculate the least cost path from Provo Station to Zion Station is to use the “Cost Path” tool. This tool requires the following settings to successfully calculate the least cost path: Input raster = Zion Station, Destination field = FID, Input cost distance raster = Cost\_Distance, Input cost backlink raster = Backlink1, and Path type = EACH\_CELL. With the least cost path now calculated, the results can be displayed on the map by converting the least cost path raster to a polyline and then selecting “Add to Display”.

### Deliverables

Using the data described above, construct a single ModelBuilder model that will prepare all of your input data for the least cost path analysis, and then conduct the analysis. As noted above, you are to find the least expensive route for a FrontRunner Extension to Zion National Park within the six aforementioned counties.

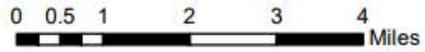
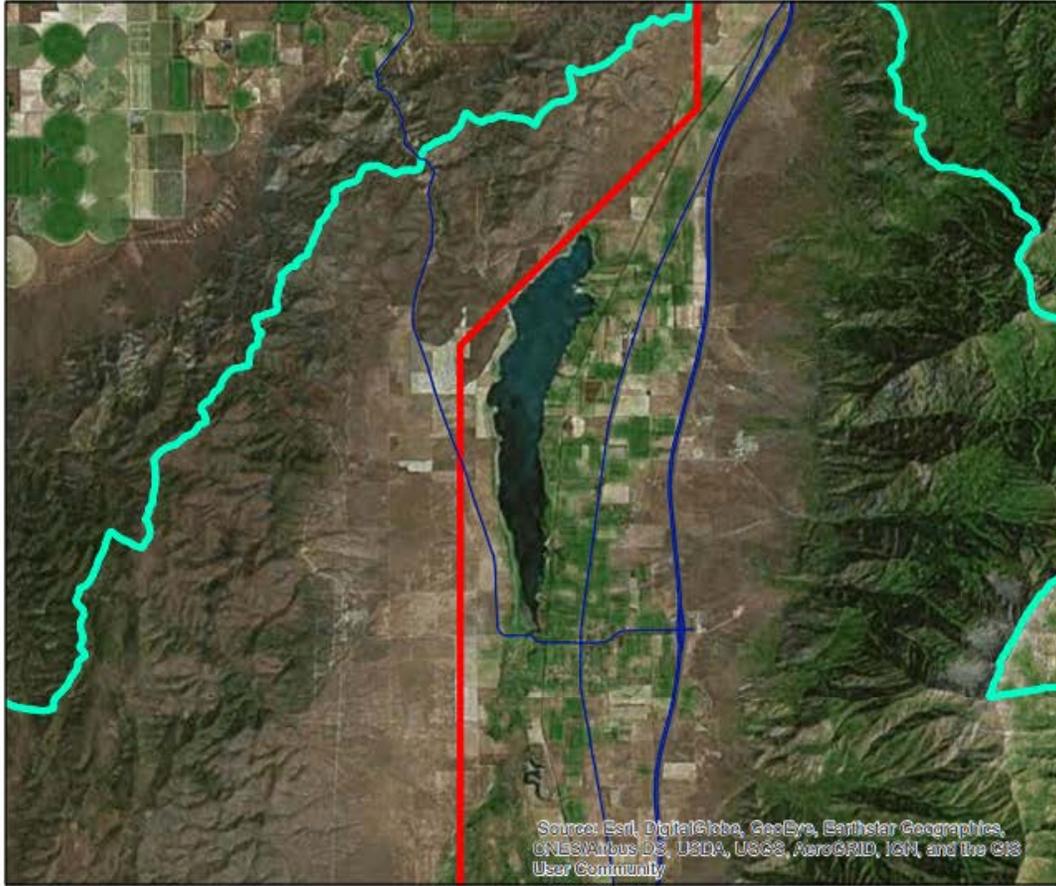
Prepare a report in the form of a word document that contains a screenshot of your model that clearly shows all elements of the model, a list of the steps that were taken in the model building process, and a final map of your results. Make sure to review over the rubric at the end of this chapter for the full requirements for the laboratory exercise.

### References

Utah Transit Authority. Station Addresses. (2017)  
<https://www.rideuta.com/Rider-Info/Station-Addresses>

Example Map

### Zion Frontrunner Extension

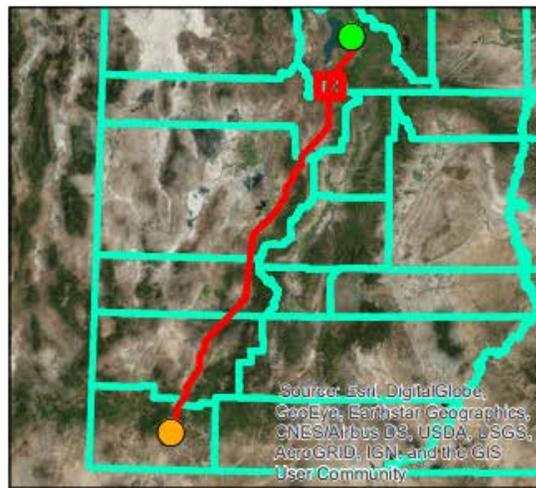


**Legend**

- Utah Highways
- FrontRunner Route
- Provo Station
- Zion Station
- Counties



Zion Frontrunner Extension Lab  
Date  
Projection



### Rubric for Least Cost Path Extension for FrontRunner Rail

Item	Points
Assignment Title, Author Name, Date, Course Name	/5
Brief summary of the requirements of the project	/5
Describe your model <ul style="list-style-type: none"> <li>• List each of the tools used: (2 pts)</li> <li>• List tool settings applied for the analysis (could someone repeat the assignment using your lab report?): (2 pts)</li> <li>• List all input, intermediate, and output datasets: (2 pts)</li> <li>• Describe each input dataset including type (point, line, polygon, raster) and the source of the data: (2 pts)</li> <li>• Describe each output dataset (point, line, polygon, raster): (2 pts)</li> </ul>	/10
<ul style="list-style-type: none"> <li>• One or more full pages (<b>8.5x11</b>) showing your model (5 pts)</li> <li>• All text is readable (<b>10 point font minimum</b>) (3 pts)</li> <li>• All tools and data sets are shown (2 pts)</li> </ul>	/10
<ul style="list-style-type: none"> <li>• Describe the path that the FrontRunner extension takes. Does the extension diverge from I-15 at any point? If so, why? (2 pts)</li> <li>• Are your results as expected or did you find anything interesting or different than expected? (3 pts)</li> </ul>	/5
Make a full page ( <b>8.5x11</b> ) map showing the results of your Zion FrontRunner Extension analysis. <ul style="list-style-type: none"> <li>• Map Title: (1 pt)</li> <li>• Neat Line: (1 pt)</li> <li>• North Arrow: (1 pt)</li> <li>• Scale Bar: (1 pt)</li> <li>• Text box with author name, date, map projection: (1 pt)</li> <li>• Image of FrontRunner extension route with legend: (5 pts)</li> <li>• Clear symbology for all data layers: (1 pt)</li> <li>• Zoomed-in view showing a part of the route that is of particular interest: (1 pt)</li> <li>• Basemap or other labeled reference data: (1 pt)</li> <li>• Zoomed to an appropriate scale for viewing analysis results: (1 pt)</li> <li>• All text is legible on printed map: (1 pt)</li> </ul>	/15
<b>Bonus Task:</b> Repeat the lab exercise with a different set of data. Include in your report what data you used, how you acquired it, what, if anything, you changed to complete the exercise work. Also include an additional full page map showing your results.	Instructor's Discretion